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1998 Salinity Study of Tidal Streams in Santa Clara County

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TABLE OF CONTENTS

Page

INTRODUCTION 1

METHODS 2

RESULTS 5
    Problems With the 1997 Data 5
    1998 Data 6
    1998 Site Observations 6

DISCUSSION 9

TABLE

TABLE 1
    1998 Sampling Stations and Corresponding "Yellow Book" Maps 4

FIGURES

FIGURE 1
    1997 Sampling Locations and Salinity Levels 10
FIGURE 2
    1998 Sampling Locations and Salinity Levels 11

INTRODUCTION

The purpose of this study is to help define maximum annual salinity levels, salinity gradients, and general locations of the extent of saline water intrusion in the tidal streams of Santa Clara County. This study was conducted to provide background information to the Santa Clara Valley Water District (District) Environmental Resources Management Unit. The data were generated for internal use, and neither the data nor this report were subjected to the internal peer review that is applied to reports intended for public distribution.

This study was conducted in 1998, and is the second study of its type, following a similar study conducted in 1997 (Kook, 1997). Results of the 1998 study are presented and compared to the 1997 study results.

Northern Santa Clara County is within the south San Francisco Bay watershed. Several of the county's streams are tidal in their lower reaches due either to a direct connection with the Bay or its major tidal sloughs. Tidal watercourses, San Francisquito Creek and Coyote Slough, define the boundaries of Santa Clara County with its northern neighbors, San Mateo and Alameda Counties, on both west and east shores of the Bay. The entire northern edge of the county between these boundaries is traversed by a series of tidal marshes, streams, sloughs, and salt ponds.

Salinity levels on tidal streams influence the types and distribution of associated tidal plant and animal communities. These biological communities can also be affected by the hydrologic regime and, therefore, the general locations of the interface between the downstream tidal and upstream nontidal regions of the streams are of interest. In addition to influencing community patterns, both the salinity gradient and tidal status also either directly or indirectly influence the distribution of individual species, including several special-status species such as salt marsh harvest mouse (*Reithrodontomys raviventris raviventris*), California clapper rail (*Rallus longirostris obsoletus*), and California red-legged frog (*Rana aurora draytonii*).

This study documents the salinity characteristics on all tidal watercourses in the county once a year. The sampling is timed to coincide with the time of year in which salinity levels in the South Bay system are typically at their maximum (late summer and fall). Sampling is conducted at 1,000- to 2,000-foot intervals, once on each stream, during the course of a single high tide event. Sampling is performed at the highest tides during which both the overall salinity within the streams and the tidal water's maximum intrusion upstream are expected to be at their highest levels.

This study provides only "snap shot" view estimates for the near maximum salinity levels within the creeks and the near maximum upstream limit of saline water intrusion for this particular year. Actual locations of particular salinity levels and the extent of salinity influence are variable over both very short (as little as hourly) and long periods of time. Tidal heights and salinity levels fluctuate yearly, seasonally, and daily due to a multitude of variables including recent rainfall, annual rainfall, urban runoff and other anthropogenic water inflow, and large scale climatic and gravitational conditions.

METHODS

Surveys were conducted on all 16 tidally influenced streams in Santa Clara County. A similar study was conducted by Laughing Creek Environmental Analysis in 1997 (Kook, 1997). All stations reportedly sampled during the 1997 study were sampled in 1998 using the District's "Maps of Flood Control Facilities and Limits of 1% Flooding" ("Yellow Book") to locate corresponding station numbers and positions. Table 1 contains a list of all creeks and stations sampled during the 1998 study.

The sampling for 1998 took place from September 8 through November 5, 1998. Prior to this time period, Santa Clara County received, on average, less than 0.08 inches of rain for the 1998 water year. During the sampling period, the Santa Clara County accumulated an average of 0.68 inches of rain which occurred toward the end of the sampling period in early November.

Working under the assumption that higher tides carry a greater volume of water and, therefore, drive the tidal limits of a creek further upstream, sampling only took place during "spring tides" predicted to be 5.5 feet (MLLW) or higher at the Golden Gate Bridge.

The National Oceanic and Atmospheric Administration predicts that high tides reach the South San Francisco Bay approximately 1 hour and 15 minutes after high tide at the Golden Gate Bridge. Therefore, each sampling period began no earlier than the predicted high tide at the Golden Gate Bridge and ceased 3 hours later (i.e., sampling began approximately 1 hour before and ended 2 hours after high tide in the South Bay). Creeks were sampled in their entirety within one sampling session. In two instances, on Permanente Creek and San Tomas Aquino Creek, the time period had to be extended slightly to finish the sampling effort on these creeks.

Sampling sessions began at the downstream end of each stream, at the 0+00 station (i.e., the mouth of each creek) when access permitted, and proceeded upstream in 1,000-foot increments until two consecutive stations registered less than 1.0 part per thousand (ppt) on the salinity meter. Access was limited on Guadalupe Slough, Coyote Creek, and Guadalupe River/Alviso Slough (Refer to Table 1 for lower access stations). Thousand-foot station locations were approximated in the field using both the "Yellow Book" maps and the odometer on the District vehicle. Corresponding Global Positioning System (GPS) coordinates were taken at each station, using a Trimble Pro XRS receiver with a TSC-1 data collector accurate to sub-one meter. All coordinates were subsequently downloaded from the GPS unit and used to create an ArcView Geographic Information System (GIS) map of all 1998 sampling locations. Satellite coverage and, therefore, GPS coordinates could not be acquired on the Sunnyvale West Channel from Stations 0+00 to 40+00.

Sampling for all stations took place within the main channel. In many places, this required an extensive walk through marsh and emergent vegetation to reach open water. (Refer to Appendix A for site access notes on each stream.)

A newly calibrated YSI Model 30 salinity, conductivity, and temperature meter was used to measure salinity in ppt and temperature in degrees Celsius. Because stratification is a potential feature on tidal streams, salinity and temperature measurements were taken at quarter of a meter depth increments (0.25 m), to a maximum depth of 1.0 m when possible. Additional data recorded at each station included: station number, time of sampling, general vegetation features, status of the tide (incoming, slack, or outgoing), and estimated tidal elevation (overbank, at bank, or below bank). General data recorded for each stream included: date, stream name, and the predicted tide height at the Golden Gate.

Data was transferred into ArcView GIS to produce maps for both the 1997 and 1998 sampling seasons (Figures 1 and 2).

TABLE 1
1998 Sampling Stations and Corresponding "Yellow Book" Maps

Facility Name	Sampling Limits	"Yellow Book" Maps (Page Numbers)
San Francisquito Creek	0+00 – 110+00	1, 2
Matadero Creek	0+00 – 100+00	2, 17
Barron Creek	0+00 – 10+00	17
Adobe Creek	0+00 – 130+00	2, 17
Permanente Creek	0+00 – 138+00	17, 32
Stevens Creek	0+00 – 130+00	17, 18, 32
Sunnyvale West Channel	0+00 – 60+00	19, 33, 34
Sunnyvale East Channel	0+00 – 80+00	34
Guadalupe Slough	300+00 – 330+00	34
Calabazas Creek	0+00 – 50+00	34
San Tomas Aquino Creek	0+00 – 100+00	34
Guadalupe River/Alviso Slough	200+00 – 300+00	19, 34, 35
Coyote Creek	390+00 – 550+00	5, 20
Lower Penitencia Creek	0+00 – 60+00	5, 20
Berryessa Creek	0+00 – 60+00	20, 21
Calera Creek	0+00 – 20+00	21

RESULTS

Problems With the 1997 Data

Several problems were encountered attempting to compile an ArcView GIS map using the GPS data reported by Kook, 1997.

1.) From the GPS data collected, it appears that Calera Creek was not sampled, rather Wrigley-Ford Creek was sampled and erroneously labeled Calera Creek.

2.) From the GPS coordinates collected, it appears that Sunnyvale West Channel was not sampled, rather the drainage channel adjacent to the Sunnyvale Sewage Treatment Plant was sampled and erroneously labeled the Sunnyvale West Channel.

3.) Guadalupe River Stations 200+00 and 210+00 were not sampled. According to the 1997 GPS data, sampling for these stations occurred on the Leslie Salt Company (Cargill) property, salt pond A-8, rather than on the Guadalupe River.

4.) According to the GPS coordinates, the following station numbers were not sampled in the correct areas: Adobe Creek Stations 10+00, 20+00, 30+00, 40+00, 50+00, 60+00, and Stevens Creek Stations 70+00, 80+00, 90+00, and 100+00 were all sampled approximately 1,000 feet upstream from the corresponding "yellow book" positions; Guadalupe River Station 280+00 was sampled approximately 2,000 feet upstream of the corresponding "yellow book" position; Coyote Creek Stations 430+00, 450+00, 490+00, and 510+00 were sampled approximately1,500 feet downstream from the corresponding "yellow book" positions; and Berryessa Creek Stations 0+00 and 10+00 were sampled approximately 1,000 feet downstream of the corresponding "yellow book" positions.

5.) GPS data was stored incorrectly for Barron Creek at Station 0+00; Adobe Creek at Stations 70+00, 80+00, 90+00, 100+00, 110+00, 120+00, and 130+00; and for the entire sampling session on Permanente Creek. Therefore, "yellow book," 1,000-foot station increments were substituted in the absence of GPS coordinates to create the GIS map.

6.) Although the following stations were sampled for salinity, no GPS coordinates were recorded for San Francisquito Creek Stations 0+00, 10+00, and 20+00; Adobe Creek Station 0+00; Stevens Creek Stations 0+00, 10+00, 20+00, 30+00, and 40+00; Calabazas Creek Station 25+00; San Tomas Aquino Creek Stations 40+00 and 45+00; Lower Penitencia Creek Station 50+00; and Berryessa Creek Stations 0+00 and 20+00. In the absence of GPS coordinates, 1,000-foot station increments from the "yellow book" were substituted to create Figure 1.

Figure 1 illustrates the sampling stations and salinity levels measured from the 1997 salinity report. Both the actual sampling stations, where GPS data was valid, and the "yellow book" substituted stations, where GPS data was either faulty or nonexistent, are depicted in the figure.

1998 Data

Both the 1997 and 1998 data show similar declining trends in the salinity gradient as sampling progressed further upstream. The 1998 data, however, shows that salinity levels along the Bay margin have declined since the 1997 study.

Figure 2 illustrates the location of each sampling station (identified from GPS coordinates) and the respective salinity levels (measured at a quarter of a meter depth) recorded during the 1998 study. In general, salinity levels were highest along the Bay margin and declined slowly as sampling progressed further upstream. Creeks in the Northwest Flood Control Zone which discharge directly into San Francisco Bay maintained higher salinity levels farther upstream than creeks in the North Central, Central, and East Zones which discharge into tributaries of the Bay. Access to the lower reaches on Guadalupe Slough, Alviso Slough, and Coyote Creek was unavailable.

The functioning tide gate at the confluence of Adobe and Matadero Creeks limited the tidal influence on these creeks and substantially reduced their salinity levels along the Bay margin. The water level was approximately 10 feet higher and salinity levels were up to 4.5 ppt higher on the "Bay side" of the tide gate than on the "creek side" of the tide gate.

Both Barron and Calera Creeks, located further upstream in their respective watersheds, did not appear to be tidally influenced based on salinity readings less than 0.5 ppt and personal observations of these creeks flowing downstream while the tide was still incoming.

Sampling at depth typically produced either similar results to surface salinity or slightly greater salinity levels (refer to Appendix B). Creeks and sloughs which flow directly to the Bay, and were not influenced by tide gates, all followed a similar pattern with respect to salinity at depth. All of these streams displayed a salt wedge effect, where surface water salinity levels would rapidly decline while salinity measurements at depth maintained higher levels representative of previous downstream surface water measurements. (Refer to Appendix C for salinity and depth data.)

Pickleweed (*Salicornia virginica*), cordgrass (*Spartina foliosa*), atriplex (*Atriplex triangularis*), and alkali heath (*Frankenia salina*) tended to dominate the lower, salty reaches of each stream, while bulrush (*Scirpus* sp.), cattail (*Typha* sp.), willow (*Salix* sp.), and smartweed (*Polygonum* sp.) inhabited the upper, fresher reaches of each stream (refer to Appendix C).

1998 Site Observations

The following field notes specify the status of the tide (i.e., incoming, slack, or outgoing) and the tidal elevation (i.e., overbank, at bank, or below bank) for each stream during the 1998 study. Actual tidal status and elevation may differ from the below observations depending on the height of the tide and how far upstream the observer had traveled in relation to the tidal cycle. GPS station locations and photocopied maps from the "yellow book" are reported in Appendix D.

San Francisquito Creek — The high tide for this day, September 8, 1998, was 5.9 feet at 13:54 at the Golden Gate. During the sampling period, the tide continued to come in until approximately 15:27 at Station 60+00. The tide was consistently overbank until just upstream of Highway 101 at Station 80+00. Further upstream from this point, the tidal elevation consistently remained below the top of bank. The creek went dry by Station 110+00.

Matadero Creek — The high tide for this day, September 9, 1998, was 6.1 feet at 14:35 at the Golden Gate. Tide height and status are irrelevant on this creek due to the tide gate at Station 0+00. The water level was approximately 10 feet higher and salinity readings were 4.5 to 2.4 ppt higher on the Bay side of the tide gate than on the creek side.

Barron Creek — The high tide for this day, September 9, 1998, was 6.1 feet at 14:35 at the Golden Gate. This creek, however, is most likely not tidally influenced based on salinity readings less than 0.5 ppt.

Adobe Creek — The high tide for this day, October 5, 1998, was 6.0 feet at 11:56 at the Golden Gate. Tide height and status are irrelevant on this creek due to the tide gate at Station 0+00. The water level was approximately 10 feet higher and salinity readings were 4.5 to 2.4 ppt higher on the Bay side of the tide gate than on the creek side.

Permanente Creek — The high tide for this day, October 6, 1998, was 6.2 feet at 12:33 at the Golden Gate. During the sampling period, the tide continued to come in until approximately 14:10. The tide was consistently overbank until just downstream of Charleston Road at Station 110+00. Upstream of this point, the tidal elevation consistently remained below the top of bank. Upstream of Charleston Road (Station 120+00) does not appear to be tidally influenced due to the elevation of the reinforced concrete box culvert under Charleston Road which may prevent most tides from traveling any further upstream.

Stevens Creek — The high tide for this day, October 7, 1998, was 6.4 feet at 13:13 at the Golden Gate. During the sampling period, the tide continued to come in until approximately 15:45 at Station 90+00. Additionally, the tide was consistently overbank until Station 90+00. Further upstream from this point, the tidal elevation consistently remained below the top of bank. Upstream of Station 110+00 does not appear to be tidally influenced, based on salinity readings less than 0.5 ppt and personal observation of the creek flowing downstream.

Sunnyvale West Channel — The high tide for this day, October 21, 1998, was 5.6 feet at 12:37 at the Golden Gate. The tide was slack when the sampling took place at 14:10. The tidal elevation was at the top of bank for Stations 0+00 to 10+00 and below the bank for the rest of the sampling stations.

Sunnyvale East Channel — The high tide for this day, November 2, 1998, was 6.3 feet at 9:39 at the Golden Gate. During the sampling period, the tide continued to come in until approximately 11:50 at Station 70+00. The tide was consistently overbank until Station 50+00, at which point the tidal elevation was at bank level. By Station 80+00, the tidal height was below the top of bank.

Guadalupe Slough — The high tide for this day, November 2, 1998, was 6.3 feet at 9:39 at the Golden Gate. During the sampling period, the tide continued to come in until approximately 11:50. The tidal elevation was consistently overbank for the slough even as the tide receded.

Calabazas Creek — The high tide for this day, September 10, 1998, was 6.1 feet at 15:20 at the Golden Gate. The weather was too windy to determine when exactly the tide stopped coming in; the tidal elevation, however, was consistently overbank throughout the entire sampling session.

San Tomas Aquino Creek — The high tide for this day, September 10, 1998, was 6.1 feet at 15:20 at the Golden Gate. The weather was too windy to determine when exactly the tide stopped coming in; the tidal elevation, however, was consistently overbank until just upstream of Station 90+00. Upstream of Station 100+00 does not appear to be tidally influenced, based on salinity readings less than 0.6 ppt and personal observation of the creek flowing downstream.

Guadalupe River/Alviso Slough — The high tide for this day, October 9, 1998, was 6.3 feet at 14:43 at the Golden Gate. During the sampling period, the tide continued to come in until approximately 17:10 at Station 270+00. The tidal height was consistently overbank throughout the entire sampling period.

Coyote Creek — The high tide for this day, October 8, 1998, was 6.4 feet at 13:55 at the Golden Gate. During the sampling period, the tide continued to come in until 15:50 at Station 490+00. The tide was consistently overbank until Station 450+00, at which point the tidal elevation was at bank level. By Station 500+00, the tide height was below the top of the bank.

Lower Penitencia Creek — The high tide for this day, November 4, 1998, was 6.7 feet at 10:57 at the Golden Gate. The tide continued to come in the entire sampling period. The tidal elevation remained overbank until Station 50+00 and below the top of bank further upstream.

Berryessa Creek — The high tide for this day, November 5, 1998, was 6.8 feet at 11:39 at the Golden Gate. The tide continued to come in the entire sampling period but did not appear to influence the creek upstream of Station 20+00. The tidal elevation was overbank until Station 10+00 and below the top of the bank further upstream. Upstream of Station 30+00 does not appear to be tidally influenced, based on salinity readings less than 0.5 ppt and personal observation of the creek flowing downstream.

Calera Creek — The high tide for this day, November 4, 1998, was 6.7 feet at 10:57 at the Golden Gate. Calera Creek does not appear to be tidally influenced upstream of the confluence with Berryessa Creek. The tide was still coming in on Berryessa Creek, yet the creek was flowing downstream on Calera Creek at Station 10+00.

DISCUSSION

The 1998 sampling data shows that salinity levels have declined slightly along the Bay margin since the 1997 study. This trend is consistent with preliminary water quality data collected by the United States Geological Survey (USGS) at the Newark Slough (Station 34: latitude 37°29.7′; longitude 121°5.6′) and Calaveras Point (Station 36: latitude 37°28.3′; longitude 121°3.9′) sampling stations in the south San Francisco Bay. During the 1997 study period, from September to December, the salinity levels at USGS Stations 34 and 36 ranged from 28.48 to 29.77 ppt (USGS preliminary data from website). During the 1998 study period, from September to November, the salinity levels at the same stations ranged from 19.65 to 25.59 ppt (USGS preliminary data from website). The extreme rains and freshwater influx from the 1997 to 1998 El Niño weather patterns appear to have caused the decline in salinity levels throughout the entire San Francisco Bay for the 1998 water year.

The functioning tide gate at the confluence of Adobe and Matadero Creeks had a substantial effect on the salinity levels of these streams in 1998. The 1997 results do not illustrate this disparity; however, the tide gate was dysfunctional during the 1997 sampling period.

Smaller upstream tributaries like Barron and Calera Creeks do not appear to be tidally influenced although the larger streams to which these drain, Adobe and Berryessa Creeks, respectively, are tidally influenced.

In general, sampling at depth produced either similar results to surface water salinities or slightly greater salinity levels. It would be useful to sample deeper, when possible, especially at stations where the surface salinity suddenly declines. Deeper sampling profiles may be able to reveal the full upstream extent of the salt wedge.

For future studies, it would be beneficial to sample further downstream in the North Central, Central, and East Flood Control Zones, along Guadalupe Slough, Alviso Slough, and Coyote Creek, respectively, to see whether there is a shift in salinity levels along the Bay margin from Palo Alto to Milpitas (west to east in the South Bay).

Working under the assumption that high tides reach the south San Francisco Bay approximately 1 hour after the Golden Gate, proved to be problematic in a few instances. When sampling streams in the East Zone (Coyote Watershed), the tide appeared to take longer than 1 hour to reach the upper extent of these tributaries. A more accurate prediction of when high tides reach the South San Francisco Bay would, in the future, allow for more accurate salinity measurements of South Bay tributaries.

In future studies, it would be favorable to establish a fixed point or station on each stream from which to determine the tidal status (i.e., incoming, slack, or outgoing). This may provide a more accurate, fixed account of the timing of the tidal cycle in the South Bay, rather than an account from the observers perspective, which ultimately depends upon how far upstream the observer is when the tidal status changes.

A more detailed plant list for each station, broken down to the species level, would be beneficial in establishing a vegetation – salinity association.

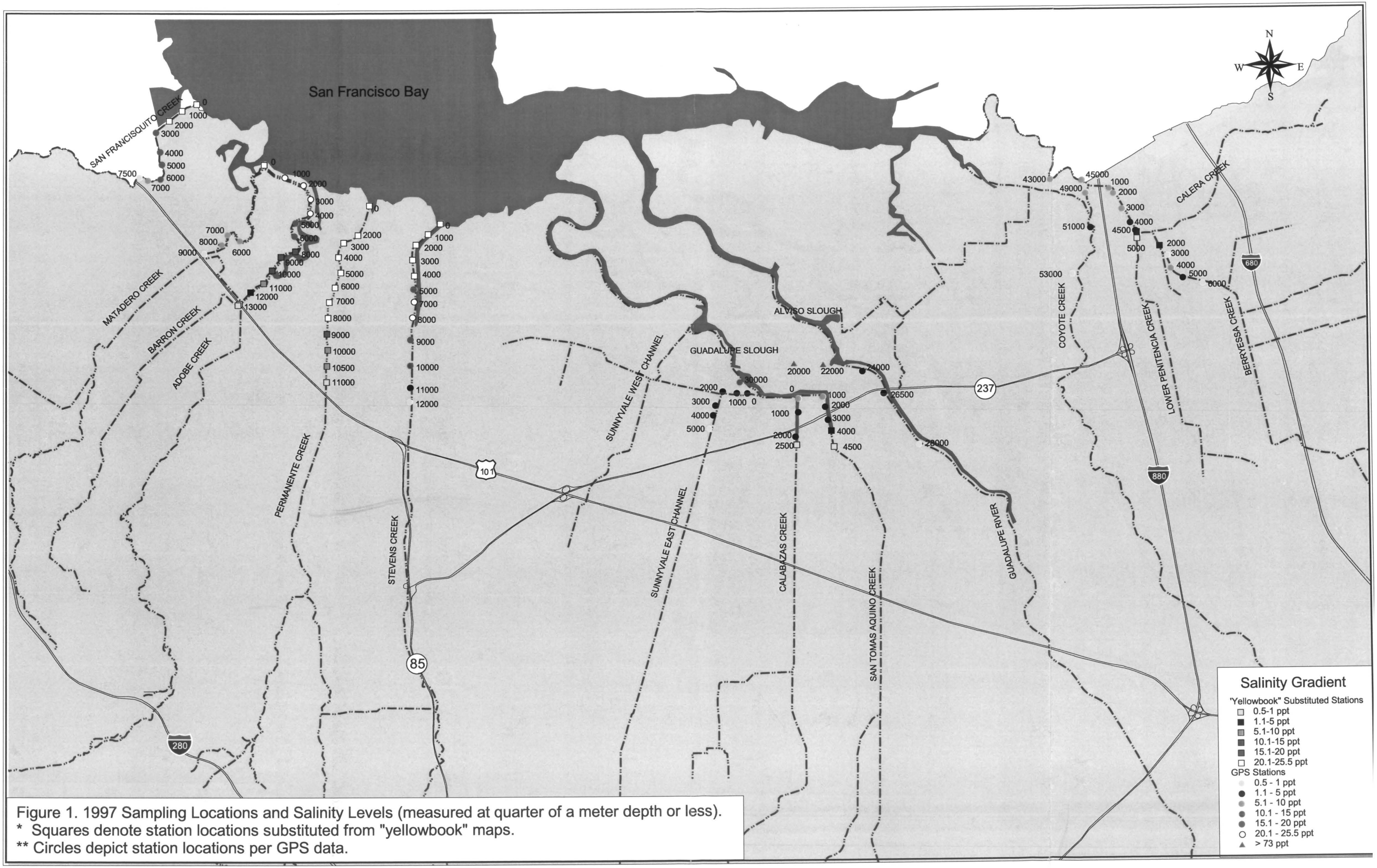
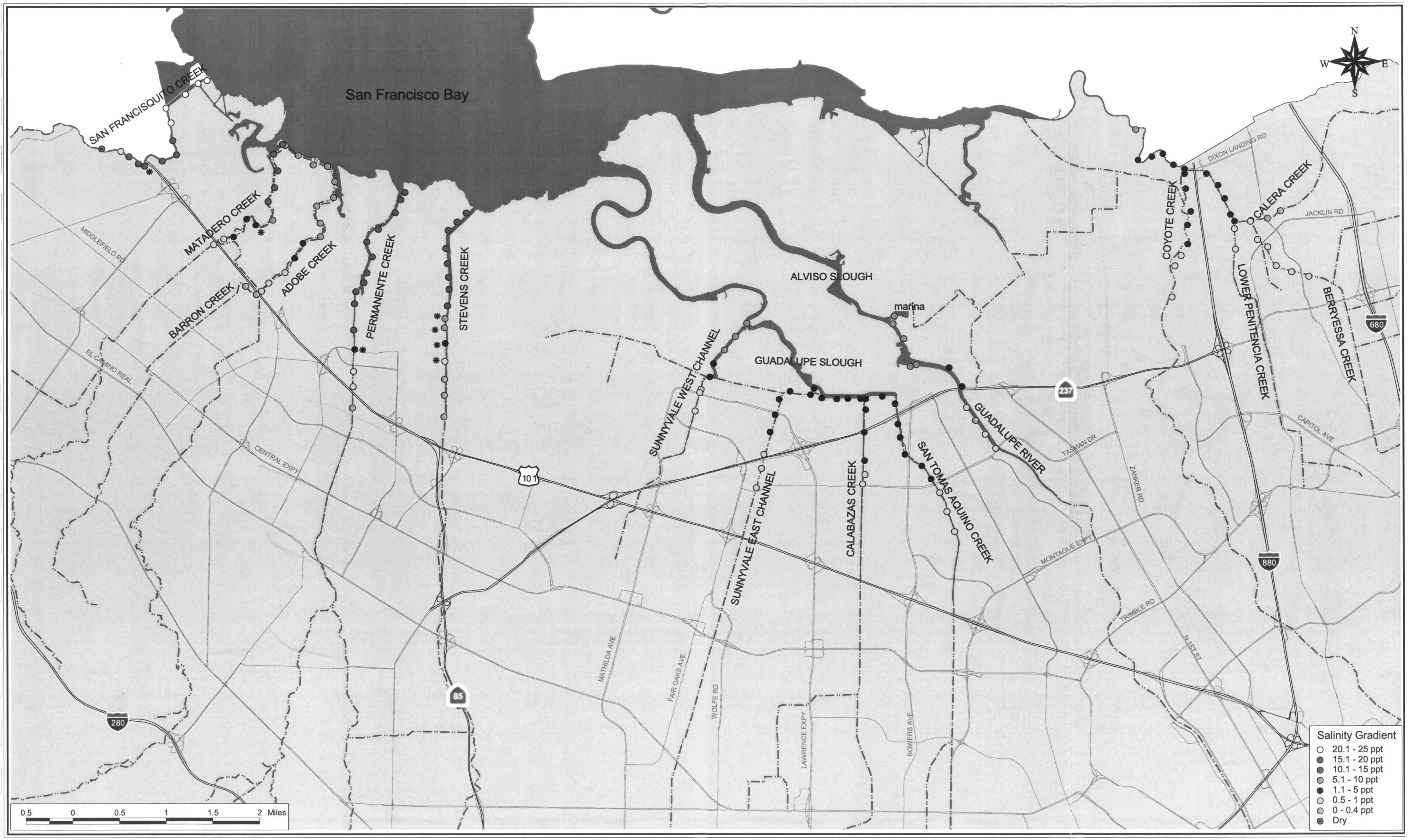


Figure 1. 1997 Sampling Locations and Salinity Levels (measured at quarter of a meter depth or less).

* Squares denote station locations substituted from "yellowbook" maps.

** Circles depict station locations per GPS data.



1998 Sampling Locations and Surface Salinity Levels.

✱= Stations where salinty measurements at depth are higher than the depicted surface salinity values.

Santa Clara Valley Water District